RL-TR-95-281
In-House Report
January 1996

SYNBAD: A DISTRIBUTED INTERACTIVE SIMULATION (DIS) ENVIRONMENT FOR C3I CAPABILITY ASSESSMENT

Alex F. Sisti,(Rome Laboratory) and
Kevin C. Trott, (PAR Government Systems)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

Rome Laboratory
Air Force Materiel Command
Rome, New York

This report has been reviewed by the Rome Laboratory Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be releasable to the general public, including foreign nations.

RL-TR- 95-281 has been reviewed and is approved for publication.

APPROVED: Ronald W Cwirko

RONALD CWIRKO, Chief
Signal Intelligence Division
Intelligence & Reconnaissance Directorate

FOR THE COMMANDER:

JOSEPH CAMERA
Technical Director
Intelligence & Reconnaissance Directorate

If your address has changed or if you wish to be removed from the Rome Laboratory mailing list, or if the addressee is no longer employed by your organization, please notify Rome Laboratory/ (IRAE), Rome NY 13441. This will assist us in maintaining a current mailing list.

Do not return copies of this report unless contractual obligations or notices on a specific document require that it be returned.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 1996	In-House Apr - Jun 1995

4. TITLE AND SUBTITLE
SYNBAD: A DISTRIBUTED INTERACTIVE SIMULATION (DIS) ENVIRONMENT FOR C^3I CAPABILITY ASSESSMENT

5. FUNDING NUMBERS
PE - 62702F
PR - 4594
TA - 15
WU - L6

6. AUTHOR(S)
Alex F. Sisti, (RL) and Kevin C. Trott (PAR Gvmt. Sys.)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Rome Laboratory/IRAE
32 Hanger Road
Rome, NY 13441-4114

8. PERFORMING ORGANIZATION REPORT NUMBER
RL-TR-95-281

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Rome Laboratory/IRAE
32 Hanger Road
Rome, NY 13441-4114

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Rome Laboratory Project Engineer: Alex F. Sisti (IRAE)/(315)330-4518

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The SYNthetic BAttlefield Development (SYNBAD) Environment is being developed at the Air Force's Rome Laboratory, and is based on current community standards and the protocols of the burgeoning world of Distributed Interactive Simulation (DIS). This report discusses its design and potential usage, describes the progress in its implementation and makes some recommendations and predictions for its future.

14. SUBJECT TERMS
Distributed Interactive Simulation (DIS), Modeling and Simulation Framework, C3I Modeling and Simulation, (Con't on Reverse)

15. NUMBER OF PAGES
24

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	U/L

14. (Con't) Weapons Effectiveness Modeling, Virtual Battlefield.

SYNBAD: A Distributed Interactive Simulation (DIS) Environment for C^{3}I Capability Assessment

Alex F. Sisti, Rome Laboratory, Griffiss AFB, NY
Kevin Trott, PAR Govt Systems Inc, New York

Abstract *The Synthetic Battlefield Development (SYNBAD) Environment is being developed at the Air Force's Rome Laboratory, and is based on current community standards and the protocols of the burgeoning world of Distributed Interactive Simulation (DIS). This paper discusses its design and potential usage, describes the progress in its implementation and makes some recommendations and predictions for its future.*

Background

Rome Laboratory has the Air Force charter for performing research and development in the technologies associated with Command, Control, Communications and Intelligence (C^{3}I), and as such, is often called upon for technical consultation, assistance and support to the Air Force and other agencies. In carrying out these duties, Rome Lab has assembled an impressive array of high quality models, simulations, databases and technical expertise, covering a wide variety of domains. For the most part, these models have historically been built in answer to the specific needs of individual customers, often dealing with only one aspect of C^{3}I (e.g., a fusion algorithm or a tactical route planner). By definition and design, they have been primarily standalone systems whose overall technical worthiness often cannot be assessed until operational fielding. While certainly qualifying as successful programs (since they do meet the stated requirements of their end-users), there is a great need for C^{3}I techniques and equipment to be assessed within the context of an end-to-end, integrated C^{3}I evaluation environment; that is, how one component affects, or is affected by, other components in the system.

The concept of such an end-to-end C^{3}I evaluation architecture is hardly new at Rome Laboratory. It was first addressed in the early 1980s, when several systems developed by and for Rome Laboratory (then Rome Air Development Center) were collected and loosely integrated into a demonstration-only assemblage; whose purpose was to functionally replicate the divisions of a (then) Tactical Air Control Center (TACC). That system, demonstrated at Rome's Battle Management Laboratory, showed potential users the "state-of-the-possible". Unfortunately, since it was limited to demonstration only, it lost some of its allure when these potential customers realized that an actual operational system, so configured, was prohibitively costly, and prone with the technical risks associated with the immature field of hardware and software component integration. Then in 1985, the first successful instance of model integration at Rome Laboratory occurred with the development of the Electronic Combat Effectiveness System (ECES) [11]. This system was designed to enhance an in-house Electronic Combat (EC) modeling capability, through the acquisition of three validated standalone models in the Air Force inventory, and their integration into an existing battlefield modeling environment. The resulting system provided RL engineers with the capability to demonstrate, validate and

evaluate various EC configurations and techniques, with greater credibility.

The real success of the Electronic Combat Effectiveness Study was not so much in demonstrating the benefits derived from integrating detailed Air Force-approved and validated models. In fact, that a system is made better by incorporating better models should be intuitively obvious. And, in retrospect, it's clear now that the point of the effort was not actually about the feasibility of effecting such a hierarchically constructed system, since other such integration efforts had been performed by and for the Government (some examples are Simulation Driver Integration, SIGINT Support Facility-Advanced Sensor Exploitation [SSF/ASE] Interface, Forward Area Processor-Advanced Sensor Exploitation [FAP-ASE] Integration, etc.), before and since the ECES contract. Certainly, people will claim that, given enough time and money, anything is doable. While the work involved in the actual interface(s) was quite labor-intensive, the developers never doubted that it could be accomplished.

Rather, the concept of model integration begs the question "Are the benefits worth the effort?" Although the ECES effort was fairly straightforward and involved only the integration of three external models, there was considerable time and money spent in determining the mappings between model inputs/outputs -- including parameter names, units, computer representation(s), etc. -- and even more in resolving event timing and synchronization issues. Ultimately, although the experience, methodologies and lessons learned were reused in subsequent integration efforts, each such effort still entailed those labor-intensive intermodel mapping and conversion activities. Coupled with that reality was that there still was no effort to try to solve the requirement for a general infrastructure to allow more seamless -- and painless -- large-scale simulation construction. Everyone in the modeling community recognized the need for this general simulation framework, but no one agency was willing to pay for its development.

Eventually, several simulation frameworks did start to emerge in the late '80s and early '90s; the Air Defense Initiative Simulation for Command and Control (ADISC^2), ASC's Joint Modeling and Simulation System (J-MASS) and The Analytic Sciences Corporation's (TASC's) Advanced Simulation Framework product are three representative systems. However, not only did this movement not solve the general requirement of the modeling community, it may have actually exacerbated the problem. Development money, already tight, was now being dispersed among several framework-related efforts, for essentially the same functionality; and with very limited consideration for reuse potential outside of each's specific dominion. The overall disposition of the modeling community (or more accurately, of funders of the modeling community), already apprehensive, grew more resolute in stating the need for a common paradigm for model/simulation construction and execution. This movement led to increased research into a variety of enabling technologies in modeling and simulation science; such as object-oriented principles, software/model reuse, hierarchical simulation, modularity, model management systems,

multiple levels of detail/resolution, model/simulation standards, distributed simulation, real-time simulation and even virtual reality [8, 9,12]. Finally, all this seemingly unrelated work began to converge into what is now known as Advanced Distributed Simulation (ADS); from which was spawned its first major implementation thrust: Distributed Interactive Simulation (DIS).

Distributed Interactive Simulation

History

Current Distributed Interactive Simulation (DIS) technology traces its roots back to the DARPA-sponsored Simulation Network (SIMNET) project, which began in 1983 and concluded in 1989. This R&D project successfully demonstrated the core technology required for networking large numbers of manned simulators, emulators and computer generated forces (CGF). It was an extremely successful program, not only for its technical contributions regarding simulator interoperability, but also for the degree to which it built a connection between the modeling community and the actual warfighters. This is turn led to increased acceptance and advocacy at all levels within DoD, the formation of the Defense Modeling and Simulation Office (DMSO), and more importantly, the growth of an officially sanctioned movement to develop a set of open system standards for distributed simulation. This movement has come to be known as Distributed Interactive Simulation (DIS).

Since the current work on DIS standards began in 1989, the level of participation has grown steadily, as evidenced by the attendance at two specific recent DIS-related conferences. The 1994 DIS standards workshop, held in Sept 1994, hosted over 1100 simulation developers and managers for the purpose of proposing message protocol and database format standards. In December of each year, the Interservice/Industry Training, Simulation and Education Conference (I/ITSEC) is held; highlighted by DIS interoperability demonstrations. In 1993, 45 organizations were involved in a DIS exercise involving over 70 simulations or simulators, located both physically at the conference and at various remote locations throughout the country. As over 7500 attendees at that conference can attest, Distributed Interactive Simulation is the current 'best solution' to modeling the synthetic battlefield.

Its Goal

From the DIS Steering Committee's May 1994 report entitled "The DIS Vision: A Map to the Future of Distributed Simulation" comes the following quote [2]:

> *The primary mission of DIS is to define an infrastructure for linking simulations of various types at multiple locations to create realistic, complex, "virtual worlds" for the simulation of highly interactive activities. This infrastructure brings together systems built for separate purposes, technologies from different eras, products from various vendors, and platforms from various services and permits them to interoperate....*

The Concept

Distributed Interactive Simulation models the virtual battlefield as a

collection of "entities" that interact with one another by means of "events" that they cause. These events may be detected by other entities and may have effects on them, which may in turn cause other events that affect other entities. The heart of DIS is a set of protocols that convey information about entities and events across a local or wide area network, connecting various simulation nodes; each of which is responsible for maintaining the status of some of the entities in the virtual world. What sets Distributed Interactive Simulation apart from traditional simulation are its design principles; the culmination of years of research and experimentation in the areas listed above. Specifically, DIS technology is based on the following design principles [1, 2]:

Entity/Event Architecture - Information about fixed (non-changing) objects in the virtual environment is assumed to be known to all simulations and need not be transmitted. Dynamic objects keep each other informed of their movements and the events that they cause through the transmission of Protocol Data Units (PDUs) that describe any changes in entity state information.

Simulation Node Autonomy - From the perspective of each simulation node, all events are broadcast and are available to all interested objects. The node at which the event was caused does not need to determine which other nodes may be interested in that event. Each receiving node is responsible for determining the effects of an event on the entities which that node is simulating. This principle of autonomy is what allows nodes to join or leave an exercise in progress without disrupting the simulation.

Transmission of "Ground Truth" Information - Each node transmits the absolute truth about the (externally observable) state of the object(s) it represents. The receiving nodes are solely responsible for determining whether their objects can perceive an event and whether they are affected by it. Degradation of information is performed by the receiving node in accordance with an appropriate model of sensor characteristics before being passed on to human operators or automated systems.

Transmission of State Change Information Only - Nodes transmit only changes in the behavior of the entities they are simulating. This is intended to minimize the unnecessary transmission and processing of data. If an entity continues to do the same thing (e.g., straight and level flight at a constant speed), the update rate drops to a predetermined minimum level.

"Dead Reckoning" Algorithms to Extrapolate State Information Between Updates - Each simulation node maintains a simplified representation of the (externally visible) state of all nearby entities, and extrapolates their last reported states until the next state update information arrives. The node simulating each entity is responsible for transmitting new state information before the discrepancy between its "ground truth" information and the extrapolated

approximations generated by the other nodes becomes too large. In order to support this, each node must maintain "dead reckoning" models of each of its own entities, and must continually compare its own ground truth state for each entity with the corresponding dead reckoning model, in order to determine when it must transmit a new update. State updates include not only location and orientation information, but also velocity and acceleration vectors that support the extrapolation.

Simulation Time - The DIS standards were developed to support human-in-the-loop simulations, primarily involving manned simulators of ground and air platforms. DIS simulations currently operate in "real time", using a performance standard of 100 milliseconds. If there are no human operators involved, it is possible to scale up DIS simulation time rates to allow faster-than-real-time operation, such as would be required to model detailed interactions between weapons systems, sensors, and tactical communications systems; which often occur at much faster rates.

The willingness of the modeling community to accept these design principles -- in many ways, coarser and more constraining than those imposed by traditional simulation -- has resulted in the definition of interoperability standards, and ultimately, the adoption of IEEE Standard 1278; the "Standard for Information Technology - Protocols of Distributed Interactive Simulation Applications, Version 1.0". But acceptance of the standards by the technical community alone is not enough to ensure consistent, non-duplicative development activity. Rather, the confirmation of upper-level management, policy-makers and money-holders is essential to furthering the growth and applicability of Distributed Interactive Simulation. The DIS technical community has worked diligently for that advocacy, and the current list of DoD sponsors includes the Defense Modeling and Simulation Office (DMSO), the Advanced Research Projects Agency (ARPA), the US Army Simulation, Training and Instrumentation Command (STRICOM) [which has been designated the lead laboratory for development of DIS], the US Army Training and Doctrine Command (TRADOC), the Naval Air Systems Command (NAVAIR), the Naval Sea Systems Command (NAVSEA), the Air Force Air Combat Command (ACC), the Air Force Ballistic Missile Defense Organization (BMDO), the Air Force Training Special Program Office, and the US Special Operations Command (USSOCOM). Other supporting agencies include the Defense Information Systems Agency (DISA), which is the DoD agent for developing information systems standards, and which will manage the Defense Simulation Internet (DSI)]; and the National Security Agency (NSA), which is developing security procedures and encryption/decryption technology for use with DIS. Furthermore, the Defense Science Board concluded in their summer study of 1992 that "All labs, test facilities, training ranges, service schools and industry should be fully networked and made DIS compatible...", and that "DIS standards and protocols should be

incorporated into all appropriate developments and procurements."

Air Force Involvement in DIS: A Two-Way Street

Although the other services (especially the Army; see references [4,5,6]) have made a strong commitment to Distributed Interactive Simulation, Air Force participation has been woefully deficient. To rectify this disarming fact, Armstrong Laboratory's Col Lynn Carroll, working in conjunction with BGen Frank B. Campbell (the Air Force Director of Modeling, Simulation and Analysis at AF/XOM), hosted the first "Air Force Advanced Distributed Simulation/Distributed Interactive Simulation (ADS/DIS) Organizational Conference" in July 1994; for the purpose of helping to define/refine the Air Force's role in the DIS arena. From that meeting (and subsequent meetings), it was obvious that a rational, coordinated position on the development of DIS within the Air Force was essential to maintaining technical currency with the rest of the DoD modeling community, but it was equally evident that the DIS community stood to gain just as much from a stronger Air Force involvement. The DIS Steering Committee's guidance document, "The DIS Vision: A Map to the Future of Distributed Interactive Simulation", lists some technical challenges facing the DIS community that could well be solved by the participation of the Air Force and its laboratories. These challenges range from purely DIS-related R&D (for example, aggregation/deaggregation of object representations; VV&A of DIS elements and exercises) to application-specific (e.g., greater emphasis on non-ground based platforms, emissions and C^4I). From that document comes the quote: "Each service currently has its own simulations and models. In many cases these models can be connected through DIS technology to provide a "jointness" in exercises at a much lower cost than developing totally new simulations."[2]

The Air Force's Rome Laboratory indeed has many models and simulations that would seem to directly address some of the current needs of the DIS community, and has the experience in both model integration and battlefield simulation. By applying these tools and this corporate experience towards developing and implementing the Synthetic Battlefield Development (SYNBAD) Environment (described in the following sections), Rome Lab will be able to support the technologies needed to answer the challenges of the DIS community at large; while at the same time, using these same DIS principles to assemble an end-to-end, integrated environment for performing C^3I evaluation studies in general.

The Synthetic Battlefield Development (SYNBAD) Environment

As with any large system, careful consideration had to be given up front as to the overall requirements of the SYNBAD Environment -- both for the present, and for its continued evolution. In essence, the primary question is: what is the overall goal of this integrated simulation environment? And, with that goal in mind, can we then intelligently design and implement this environment such that it not only meets the basic stated requirement, but also satisfies other, less obvious user needs? As a result of this requirements analysis

phase, the following five goals -- and potential purposes -- were identified:

C3I capabilities assessment The primary objective of the SYNBAD Environment, as stated above, is to provide an integrated framework in which to perform the myriad variety of C^3I analyses that Rome Laboratory has been performing for decades. These analyses, covering the entire range of Command, Control, Communications, Surveillance and Intelligence, have resulted in the development of many excellent models, simulations, tools and databases, by the individual mission directorates that make up the Lab. However, as mentioned, there has been no concerted effort to integrate those pieces such that their effectiveness -- their operational worthiness -- can be assessed in the context of an overall mission. That then is the overall goal of the Synthetic Battlefield Development Environment. Specifically, using the SYNBAD Environment, capability assessments can be performed for any number of C^3I equipment, tactics/doctrine and techniques/algorithms.

Equipment Rome Lab has been deeply involved in R&D for the development, enhancement, test and fielding of a wide variety of C^3I equipment, including jammers, intelligence handlers, Electronic Support Measures (ESM) equipment, speech enhancement equipment, communications equipment, encryption devices and radars, to name but a few. Basing the design on DIS protocols allows us to perform hybrid simulations, involving a mix of validated software and operational/prototypical hardware. In addition, some new hardware acquisitions are beginning to be required to be DIS-compatible; capable of being plugged directly into a DIS network for testing purposes.

Tactics/doctrine Unarguably the most important aspect of battle management involves the cycle of tactical/doctrinal planning, rehearsing, execution, assessment and reprogramming; in other words, the commander making the best use of the resources at his or her disposal. A major part of Rome Laboratory's mission involves research and development to integrate and automate these functions, while also adapting promising emerging technologies (e.g., neural nets, expert systems, etc) towards that end. Some of the functional areas for which Rome Lab has developed or adapted successful systems include route planning, mission planning, Air Tasking Order (ATO) generation, target nomination and electronic combat support aids, among others. Again, a DIS-based simulation framework will allow Rome Lab to accurately replicate the functions of a distributed Air Operations Center (AOC) in a synthetic battlefield.

Techniques/algorithms It is a cold fact of life in the DoD that many billions of dollars have been spent on the equipment in our inventory; much of which, unfortunately, is obsolete scant years after (and sometimes before!) becoming operational. One of the underlying tenets pervading R&D at Rome Lab

involves making better use of in-place resources, without building or buying new hardware, or performing major upgrades to existing equipment. In addition to the areas of its more traditional algorithmic development (for example, signal processing, fusion/correlation algorithms, speech processing, image processing, etc), Rome Lab has long performed "what if" scenarios, involving assessments as to the contributions of deception techniques, target cueing/tipoffs, real-time intelligence to the cockpit, and the like. These analyses, essentially cost/benefit studies, can readily be performed within the SYNBAD Environment; both driving and being driven by actual operational hardware and software.

Improvements in System Acquisition Recent studies (a July 1993 Four Star Review of Modeling and Simulation, and a 1994 Defense Science Board Task Force review) and new regulations (DoDD 5000.59, "DoD Modeling and Simulation Master Plan"; AFPD 16-10, "Modeling and Simulation Management", and AFI 16-1003, "Acquisition Modeling and Simulation Management") have resulted in a redefinition of the traditional C^3I systems acquisition cycle; one that makes greater use of modeling and simulation throughout the life cycle of new systems development. Introduced at the earliest stages, modeling and simulation will be used for validating system requirements, for evaluating design alternatives, for testing within a (synthetic) battlefield environment, for determining maintenance requirements and timelines, and for training operational users. One of the primary goals of the SYNBAD Environment is to support this new acquisition cycle concept by demonstrating the feasibility and utility of introducing modeling and simulation during the concept development and requirements definition phases. Ultimately, we see SYNBAD serving as a design validation testbed for major Air Force advanced C^3I systems acquisitions.

Research and Development In addition to the analysis-related activities described above, an obvious use of the SYNBAD Environment is for the improvement and continuation of the research and development Rome Laboratory is chartered with conducting. By design, SYNBAD users will not only be able to conduct the C^3I-related R&D alluded to above, they will also have an environment in which they can perform DIS-related development and prototyping. This includes the development and testing of DIS-compliant interfaces for existing models, simulations, tools and databases, dead-reckoning algorithms, visualizers, new Protocol Data Units (PDUs) and so on.

"Quick-Look Studies" Recently, it has become evident that there is a very real need in the DoD for an environment in which to conduct quick turn-around studies. Some of the more recent inquiries to Rome Lab include: Validation, Verification and Accreditation (VV&A) of an existing C^3I model (NORAD/USSPACECOM); studies involving providing real-time intelligence to the cockpit (Air Combat Command); a test environment for an improved software tool to support SERENE BYTE Electronic Warfare exercises (AFIWC); future Joint Intelligence, Surveillance and

Reconnaissance (JISR) system requirements (DIA) and an environment for assessing Information Warfare contributions (AIA). It is a tribute to the people and the legacy of Rome Laboratory that it was considered best-suited -- intellectually -- to perform these quick-look studies, and a travesty that it is not better equipped (or staffed) to perform them. The development of the SYNBAD Environment, suitably staffed, will provide the faculty to perform this new service.

Virtual rehearsing/training Finally, we see SYNBAD as a facility which will support mission rehearsal and training -- either at Rome Lab or remotely -- using a mix of real systems and people and validated models and simulations, and in any user-defined theater of operations. At the 11th DIS Standards Workshop, BGen Frank (Ted) Campbell stated, "Our end vision is to work in simulation for training on our wartime equipment -- not something that looks kind of like it ... but on the real equipment with which we go to war." [13]

SYNBAD Environment Design Considerations

Driven by the goals and potential uses of the SYNBAD Environment, and the technical and functional requirements it is expected to satisfy, the following design aspects were identified:

Development Approach The SYNBAD Environment is not a new facility, nor does it involve huge outlays of money for new equipment. It is instead a "system of systems"; a "virtual" environment that consists of a collection of existing hardware (computers, modems, crypto equipment, simulators, networking media, etc), software (models, simulations, toolkits, databases, networking software, security software) and technical experience at Rome Lab. It is, as stated, built around Distributed Interactive Simulation (DIS) message-passing protocols and standards, and to the maximum extent, leverages off research and development work performed at Rome Lab (e.g., in modeling and simulation science, open systems, Client-Server Environments, etc).

Functional Design As pictured in Figure 1, the Synthetic Battlefield Development (SYNBAD) Environment is designed to replicate the functions of an Air Operations Center (AOC), operating in a synthetic battlefield. These functions are represented by existing models, model abstractions and databases developed by and for Rome Laboratory; which are discussed in greater detail later in this report. The section that follows deals with the simulation framework itself; the logical makeup of the SYNBAD network (Figure 2). This environment consists of five distinct nodes, supported by a common environment database. These nodes are:

> Observer Node - This node will display the "ground truth" locations and observable status of all the entities in the simulation, through both a Plan View Display (PVD), which will display symbols overlaid on a map background, and a Stealth Display, which will display a perspective view of the synthetic environment from a specific viewpoint, and which may be attached to any entity in the simulation, or freely "flown"

through the synthetic environment like an invisible aircraft.

Computer Generated Forces (CGF) Node(s) - The CGF Node models both the friendly and enemy ground and air forces at the unit and platform levels, and their movement, combat, and radio and radar emissions, using Semi-Automated Force (SAF) technology developed under the SIMNET (and other) programs.

Sensor Node - This node is responsible for modeling friendly, near-real-time, sensor systems -- both airborne and ground-based -- and will provide a Sensor Management Display to allow the simulated sensor systems to be interactively monitored.

Intelligence Collection Node - This node models intelligence collection and exploitation for the synthetic battlefield. Initially, the Intelligence Collection Node will not model specific sensor systems, but will abstractly simulate the process of intelligence collection and exploitation through a set of parameters that describe the overall effectiveness of each intelligence discipline (e.g., SIGINT, IMINT) or domain (such as air or ground surveillance).

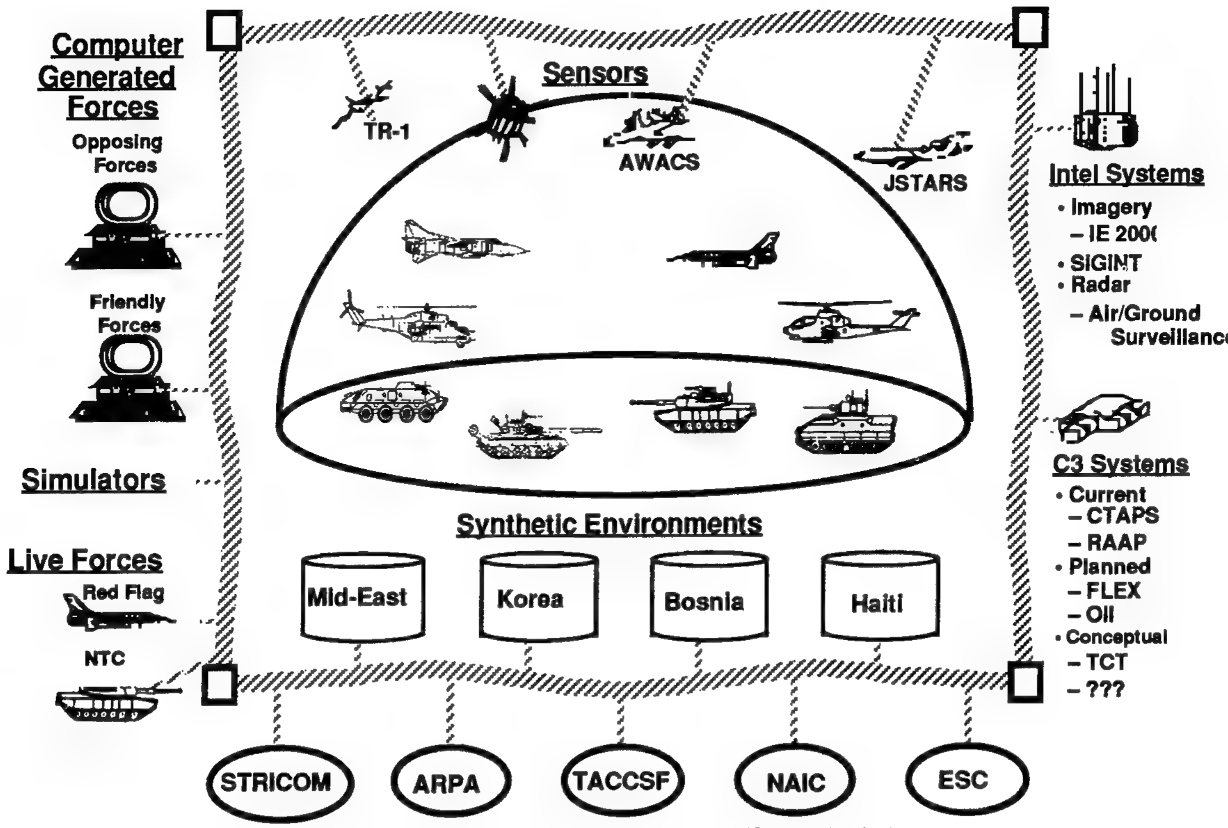

Figure 1: The Synthetic Battlefield Development (SYNBAD) Environment

Operations Node - The function of the Operations Node in the

proposed SYNBAD Environment will be to close the intelligence/operations loop by modeling the combat/operations processes of assigning air-strike assets to targets and monitoring the execution of the resulting air missions. It allows simulated friendly strike aircraft (modeled by the Computer Generated Forces node) to be assigned targets, and to execute the resulting air missions.

Support Databases - Supporting all these nodes are databases containing digital cartographic data and three-dimensional descriptions of simulated entities, as well as other pre- and post-simulation run toolkits.

Implementing the SYNBAD Environment at Rome Lab

Not surprisingly, there are several models, simulations, toolkits, databases and support technologies which map to the functional elements of the Air Operations Center, which, together with a selected suite of Commercial-off-the-Shelf (COTS) products, will populate the simulation nodes of the SYNBAD Environment described above. The following section outlines the legacy of Rome Laboratory's involvement in tactical simulation, presents some of the candidate models and simulations being considered for early inclusion into the SYNBAD Environment, and closes with a description of an ongoing contract which will result in Build 1 of the SYNBAD Environment.

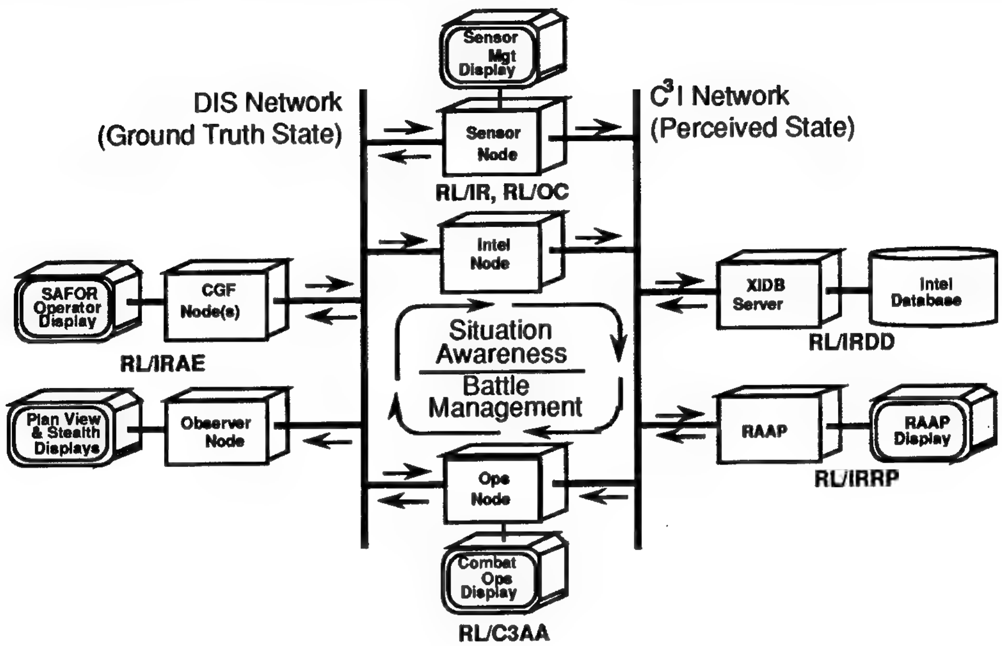

Figure 2: SYNBAD Logical Structure

Tactical C^{3}I Simulation at Rome Laboratory

Rome Laboratory has long been aware of the importance of automating and integrating the intelligence and operation

(planning, replanning and execution) aspects of the air tasking cycle as it pertains to time critical targets, and has developed technology and systems that address several aspects of this problem. These include the Advanced Planning System (APS), addressing the mission planning needs of the Combat Plans Division of the Air Operations Center (AOC); the Force Level Execution (FLEX) system, supporting the monitoring and control requirements of the AOC's Combat Operations Division; and the Rapid Application of Air Power (RAAP) system, which supports the situation analysis, target analysis, automated intelligence preparation of the battlefield, target nomination and weaponeering functions of the Enemy Situation Correlation Division (ENSCD). While the ultimate goal at Rome Laboratory is to fully integrate these systems within the context of the Contingency Tactical Automated Planning System (CTAPS) architecture, a more sensible short-term approach concerns itself with the design of a simulation infrastructure based on open systems disciplines and standards (i.e. SYNBAD), and a piecewise integration of Government and commercial software into that infrastructure, in tenable pieces, or "builds".

Distributed Interactive Simulation (DIS) for Tactical C^3I

In a recently awarded contract, PAR Government Systems Corporation, with Rome Laboratory engineers, designed the Build 1 implementation of the SYNBAD Environment, and has selected a combination of commercial and Government off-the-shelf software components for this local area DIS network at Rome Lab. This effort, entitled "Distributed Interactive Simulation (DIS) for Tactical C^3I", specifically focuses on providing DIS-based modeling and simulation support for Operations-Intelligence Integration (OII), with the goal of improving the Air Force's ability to identify and prosecute various types of time-critical targets (TCTs), using the Rapid Application of Air Power (RAAP) system. RAAP is an ideal choice for the focus of this "system of systems" integration effort; partly because it does ford the gap between the operations and intelligence processes, and partly because it is compliant with DoD Intelligence Information Systems (DoDIIS) standards through its use of the Military Intelligence Integrated Data Systems/Intelligence Database (MIIDS/IDB) database structure and data elements, as well as its adherence to TCP/IP networking standards, POSIX operating system standards and X Window System and Motif user interface standards. One shortcoming of the current RAAP system, however, is its inability to fully respond to time-critical targets, due to its dependence on the MIIDS/IDB database for intelligence updates. Interestingly enough, it was this deficiency as much as RAAP's strong points that led to its selection as a candidate system for inclusion as a SYNBAD player. It was stated earlier that the SYNBAD Environment would profit from the incorporation of existing legacy code; but conversely, other technologies stand to gain from that incorporation as well. The integration of RAAP into this local DIS-based network is an example of how existing legacy systems and other technologies stand to gain such a confederation. In this case, RAAP will now be able to accept and process realistic, dynamic simulated inputs in

addition to its continuing to access archived intelligence.

The design and operation of the overall SYNBAD Environment is best visualized

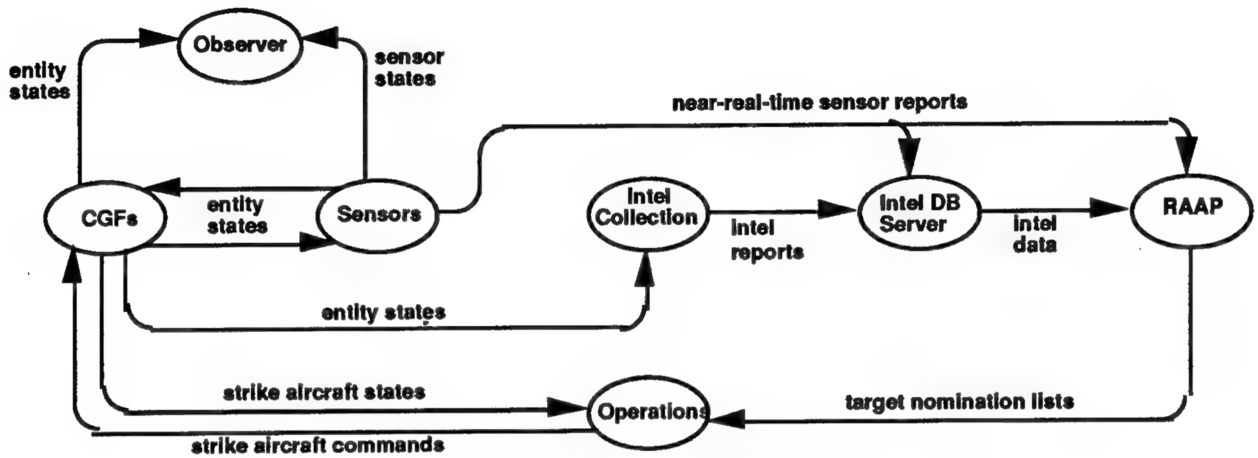

Figure 3: SYNBAD Primary Data Flows

from two vantage points: Figure 2 portrays its logical structure, which distinguishes the DIS-based portion of the network from the portion representing the CTAPS architecture, while Figure 3 depicts its primary data flows. Besides the RAAP system, all the components of the SYNBAD Environment will be assembled from a combination of commercial off-the-shelf (COTS) and Government off-the-shelf (GOTS) products, with minimal new software development. These candidate products, as they relate to the simulation nodes described earlier, are briefly discussed below.

Observer Node The function of the Observer Node is to allow a simulation to be dynamically displayed, either as it is being executed or by replaying DIS PDUs recorded during its execution. It will support two different display capabilities, in different display windows. The Plan View Display (PVD), which will display entity state information in the form of symbols on a map background, will be based on RL's Common Mapping Toolkit (CMTK) and MaK Technologies' VR-Link DIS networking toolkit. The Stealth Display capability, for displaying a three-dimensional perspective of the synthetic environment from any specified viewpoint, will be provided by MaK Technologies' Stealth Observation Vehicle product, which is based on Silicon Graphics' IRIS Performer visual simulation toolkit. Three-dimensional views of aircraft and ground vehicles will be supported by COTS models from MaK Technologies and from Viewpoint Labs. Finally, the Observer Node's data logger functionality will be provided through MaK Technologies' Data Logger application. These applications and products from MaK Technologies are widely used in the DIS community, and their inclusion confirms the commitment of SYNBAD's designers to software

reuse and conformance to community standards.

Computer Generated Forces (CGF) Node The function of the Computer Generated Forces (CGF) node is to model both the friendly and enemy ground and air forces at the unit and platform levels. A monumental coding and integration task if performed from scratch, this node will instead be based on Loral's Modular Semi-Automated Forces (ModSAF) package, recently delivered to Army STRICOM under the Advanced Distributed Simulation Technology (ADST) program [7].

Sensor Node The function of the Sensor Node in the SYNBAD Environment will be to model friendly ground-based and airborne near-real-time sensor systems. For Build 1, no specific existing sensor models are proposed for incorporation. Rather, the Sensor Node will maintain generic models of various types of tactical near-real-time sensor systems, reusing some models previously developed for Rome Laboratory. Also supporting this node will be the VR-Link product from MaK Technologies, as well as RL's Common Mapping Toolkit (CMTK) and digital cartographic data in the Air Force's Common Mapping System (CMS) format.

Intelligence Collection Node The Intelligence Collection Node will model the intelligence collection and exploitation process, representing all non-real time sources of intelligence information, as well as intelligence analysis and processing systems, such as IE2000. For Build 1, no specific collection systems will be modeled. Instead, various intelligence disciplines (e.g., SIGINT, IMINT) will be abstractly modeled as to probability of detection, error distributions, false alarm frequency, and so on. The Intelligence Collection Node will interface to the RAAP system through an intelligence database, ostensibly to the new Air Force standard Extended Integrated Data Base (XIDB). Finally, VR-Link supports this node as well.

Operations Node The function of the Operations Node in the SYNBAD Environment will be to close the intelligence/operations loop by modeling the combat-operations processes of assigning air-strike assets to targets and monitoring the execution of the resulting air missions. In Build 1, these processes will be modeled as highly simplified versions of both the Advanced Planning System (APS) and the Force Level Execution (FLEX) system, which could be integrated into the SYNBAD Environment in the future. Other reuse candidates selected to provide support to this node are the VR-Link COTS product, Rome Lab's Common Mapping Toolkit and digital cartographic data in the Air Force's Common Mapping System (CMS).

Where Do We Go From Here?

With the implementation of the Build 1 SYNBAD Environment nearly half complete, it is not too early to think

about the future. In particular, the following must be considered; not only in the area of functional system enhancements to the SYNBAD Environment (i.e. Build 2), but in its staffing and Concept of Operations and, possibly, in a revisit of Rome Laboratory's current policies and charter.

SYNBAD System Enhancements

As described above, Build 1 of the SYNBAD Environment focuses primarily on the Time Critical Target problem, and its designers have chosen the Rapid Application of Air Power (RAAP) system as the first Rome Lab tool to be made DIS-compliant (and therefore, contributing to both the DIS and RAAP user communities). In order to be able to effect a more realistic (albeit synthetic) battlefield environment, there needs to be a concerted effort to incorporate the Advanced Planning System (APS) and Force Level Execution (FLEX) systems as well. Similarly, realistic models of existing sensor systems (SIGINT, ESM, imaging sensors, etc) and intelligence collection and exploitation assets will need to be identified and integrated into the environment. In that vein, there are several other systems and ancillary emerging technologies at Rome Laboratory that can, and should, be brought to bear; for example, in the areas of speech processing, deception, virtual reality and mass storage, to name just a few. Also, in order to fulfill its design goal of being an end-to-end C^3I assessment environment, SYNBAD will require the capability to interface to real C^3I hardware, simulators or other modeling and simulation testbeds (e.g., the Air Force's Theater Air Command and Control Simulation Facility [TACCSF] or ESC's Modeling, Analysis and Simulation Center [MASC]).

Staffing and Operation

The technical goals of the SYNBAD Environment are lofty, and the overall role that Rome Laboratory will play in the C^3I effectiveness arena stands to increase dramatically. Therefore, it is our belief that the SYNBAD Environment should be staffed full-time, by both Government and contractor support personnel. Only by maintaining such staffing can we hope to respond to the quick turn-around tasking that SYNBAD was designed to address. Furthermore, a well-scoped Concept of Operations needs to be written, which identifies the focus of the SYNBAD Environment (i.e., to address current Air Force C^3I and Distributed Interactive Simulation (DIS) deficiencies), as well as the procedures (including security) related to its operation.

Rome Lab Policy and Charter

The Synthetic Battlefield Development Environment represents a change in the way we do business. Perhaps the biggest challenges ahead of us are not technical in nature, but rather in changing the way Rome Lab does (is empowered to do) business now. No one in the DoD has the time or inclination to wait two years for an analysis tool to be developed, and another year for a study to answer the crucial questions facing our military leaders in an ever-changing world. In order to more efficiently and effectively respond to the quick turn-around requests that seem to dominate the message traffic of late, we need an on-line staff of Government and contractual personnel, a better contractual vehicle for

turning these study requests into binding tasks, and a more seamless ability to accept money from different agencies (and countries), and of various colors (i.e., "types" of money). These may or may not represent challenges that are in Rome Lab's power to change, but in order for the SYNBAD Environment to fully realize its potential, these changes are essential.

Conclusion

The Synthetic Battlefield Development (SYNBAD) Environment offers Rome Laboratory an enormous opportunity to assert itself as the Air Force's center of excellence in Modeling and Simulation for C^3I system effectiveness. Based on an impressive legacy of C^3I modeling and simulation activities at Rome Lab, and adherence to community standards and to the burgeoning world of Distributed Interactive Simulation, it is an idea whose development should be ardently pursued and, once completed, vigorously publicized.

Bibliography

[1] Trott. K, "Distributed Interactive Simulation (DIS) for Tactical C^3I", PAR Government Systems Corp Technical Proposal 4001, Feb 94

[2] DIS Steering Committee, "The DIS Vision: A Map to the Future of Distributed Simulation", May 94

[3] Department of Defense, "Modeling and Simulation (M&S) Master Plan", DoD 5000.59-P, Sept 94

[4] Department of the Army, "Army Model and Simulation Master Plan", May 94

[5] Department of the Army, "The United States Army Modernization Plan: Distributed Interactive Simulation (DIS)", Jul 94

[6] Department of the Army, "Distributed Interactive Simulation (DIS) Master Plan" (draft), 1994

[7] Ceranowicz, A., "Modular Semi-Automated Forces", Loral Advanced Distributed Simulation, 1994

[8] Sisti, A., "A Model Integration Approach to Electronic Combat Effectiveness Evaluation", RL-TR-89-183, Oct 89

[9] Sisti, A., "Large-Scale Battlefield Simulation Using a Multi-Level Model Integration Methodology", RL-TR-92-69, Apr 92

[10] Trott, K. et al, "Tactical Simulation for Command, Control and Intelligence (TSC^2I)", PGSC Report, May 91

[11] Ringler, M. and Brown, G., "Electronic Combat Effectiveness Study", RADC-TR-88-276, Nov 88

[12] Trott, K. and Sisti, A., "Rome Lab's Distributed Interactive Simulation (DIS) Vision", Rome Lab briefing, Sep 94

[13] Campbell, BGen F., plenary session briefing, "11th DIS Workshop on Standards for the Interoperability of Distributed Simulations", Sept 94

☆U.S. GOVERNMENT PRINTING OFFICE: 1996-710-126-20133

MISSION
OF
ROME LABORATORY

Mission. The mission of Rome Laboratory is to advance the science and technologies of command, control, communications and intelligence and to transition them into systems to meet customer needs. To achieve this, Rome Lab:

a. Conducts vigorous research, development and test programs in all applicable technologies;

b. Transitions technology to current and future systems to improve operational capability, readiness, and supportability;

c. Provides a full range of technical support to Air Force Materiel Command product centers and other Air Force organizations;

d. Promotes transfer of technology to the private sector;

e. Maintains leading edge technological expertise in the areas of surveillance, communications, command and control, intelligence, reliability science, electro-magnetic technology, photonics, signal processing, and computational science.

The thrust areas of technical competence include: Surveillance, Communications, Command and Control, Intelligence, Signal Processing, Computer Science and Technology, Electromagnetic Technology, Photonics and Reliability Sciences.